NAL PROPOSAL No. 116

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INTERACTION OF HIGH ENERGY PROTONS IN NUCLEAR EMULSIONS LOADED WITH B^{10} and LiF

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Abstract

An experiment is proposed to expose nuclear emulsions loaded with B^{10} and LiF to high energy protons at 100 GeV, 150 GeV and 200 GeV. The purposes are: (i) to measure the total cross-sections at these incident energies, (ii) to investigate charged multiplicity as a function of energy, (iii) to investigate the angular distribution and development of hadron showers in collisions of protons with nuclei.

Present Status.

Our present experimental knowledge of high energy interactions of hadrons can be summarised as follows:

(i) The accelerator data[1] (up to 70 GeV/c) show that the total cross sections of hadrons on protons have stopped decreasing!

(ii) The Echo Lake data[2] (up to 800 GeV/c) on the total inelastic cross sections of hadrons on protons cannot distinguish between a constant value and an increasing trend. Recent satellite data obtained by Grigorov et al.[3] show, on the other hand, a 20% increase in total p-carbon inelastic cross section in the energy range 20 - 200 GeV/c, the corresponding p-p total inelastic cross section increases less slowly.

(iii) The best fit for the charged multiplicity observed at accelerator energies (up to 30 GeV/c) and in the Echo Lake experiment is $\sim$ a log Q, where Q is the production energy available in the c.m. frame. This would be consistent with the multiperipheral model[4]. However, a behaviour $\sim bE^{\frac{1}{4}}$, consistent with the isobar-pionization model[5] is not ruled out. The multiplicity distribution is Poisson. The work of Dobrotin et al.[6] is consistent with these observations.

(iv) The angular distributions still need considerable amount of work - as witnessed by the fact that the experiments cannot yet agree on whether - in p-p collisions - the distribution is bimodal (2 fireballs, bremsstrahling, isobar + pionization etc.)[7] or it is a soft pion continuum as required by the multiperipheral model.

Proposed Experiment.

We propose the irradiation, by 100 GeV, 150 GeV and 200 GeV protons of small stacks of emulsions including several pellicles loaded with microcrystals of B^{10} or LiF ($\sim$ 1% by weight). The purpose of loading the emulsion with these elements ($\bar{A} \simeq 12$) is to allow a study to be made of interactions in light nuclei, thus enabling the emulsion events to be separated into two groups (gelatine: $\bar{A} = 14$) and a heavy group (Ag,Br; $\bar{A} = 92$). In this way, it is hoped that information could be obtained on the dependence of the multiplicities on the atomic weight of the target nucleus[8,9]. The existing scanning and measuring facilities at Barcelona, Ottawa and Strasbourg will ensure prompt results - part of the facilities at Ottawa include a flying spot microscope for semi-automatic scanning. There will be no fast particle momentum measurements and no mass identification - we do not consider these as serious objections to a first survey experiment. We propose that the irradiation of the emulsions be performed as soon as possible after beam switch-on at Batavia - so that the multi-particle production results of the experiment can be utilised in future, more ambitious ventures.

Our modest beam requirements are a flux of 10^6 protons per pulse spread fairly uniformly over an area $\sim$ 10 cm x 5 cm. An exposure for $\sim$ 5 minutes is called for at each energy. We have had preliminary discussions with Dr. Tom White and Dr. Klaus Pretzl of the Beam Design Group and our understanding is that by suitable closing down of the slits and defocussing of the secondary beam there is no difficulty in meeting these beam requirements. By operating the beam transport system near the kinematic limit, the contamination of the proton beam by pions will be made negligible. Preliminary theoretical estimates indicate that this is even true at 150 GeV/c when the primary energy on the production target is 200 GeV/c.

More precise specifications on flux, spot size, experimental location in Area 2 should be decided upon after discussions with the NAL staff. Should these discussions indicate a very ready availability of an exposure at 400 GeV/c, we would welcome it. In comparison with other published cosmic ray emulsion experiments in a similar energy range, we shall have a marked improvement in our knowledge of the beam flux, beam purity, and the statistics we expect to accumulate.

Expected Physics Output.

(i) Total cross section, of protons on complex nuclei, as a function of energy.

(ii) Charged multiplicity distribution and variation with energy E, accurate enough to resolve the ambiguities mentioned earlier.

(iii) Accurate statistical information on hadron shower development. This would be excellent information for design of hadrometers.

(iv) Angular distributions in p-nucleus peripheral collision. Our experience in processing emulsions for lower energy exposures gives us confidence that we can keep distortions and non-uniformity in development to a minimum-spatial resolution of $\sim$ 1 micron is expected to be achieved without any difficulty.

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